Technology Transfer in the Defense Acquisition System

Strategic Planning and Prioritization Overview

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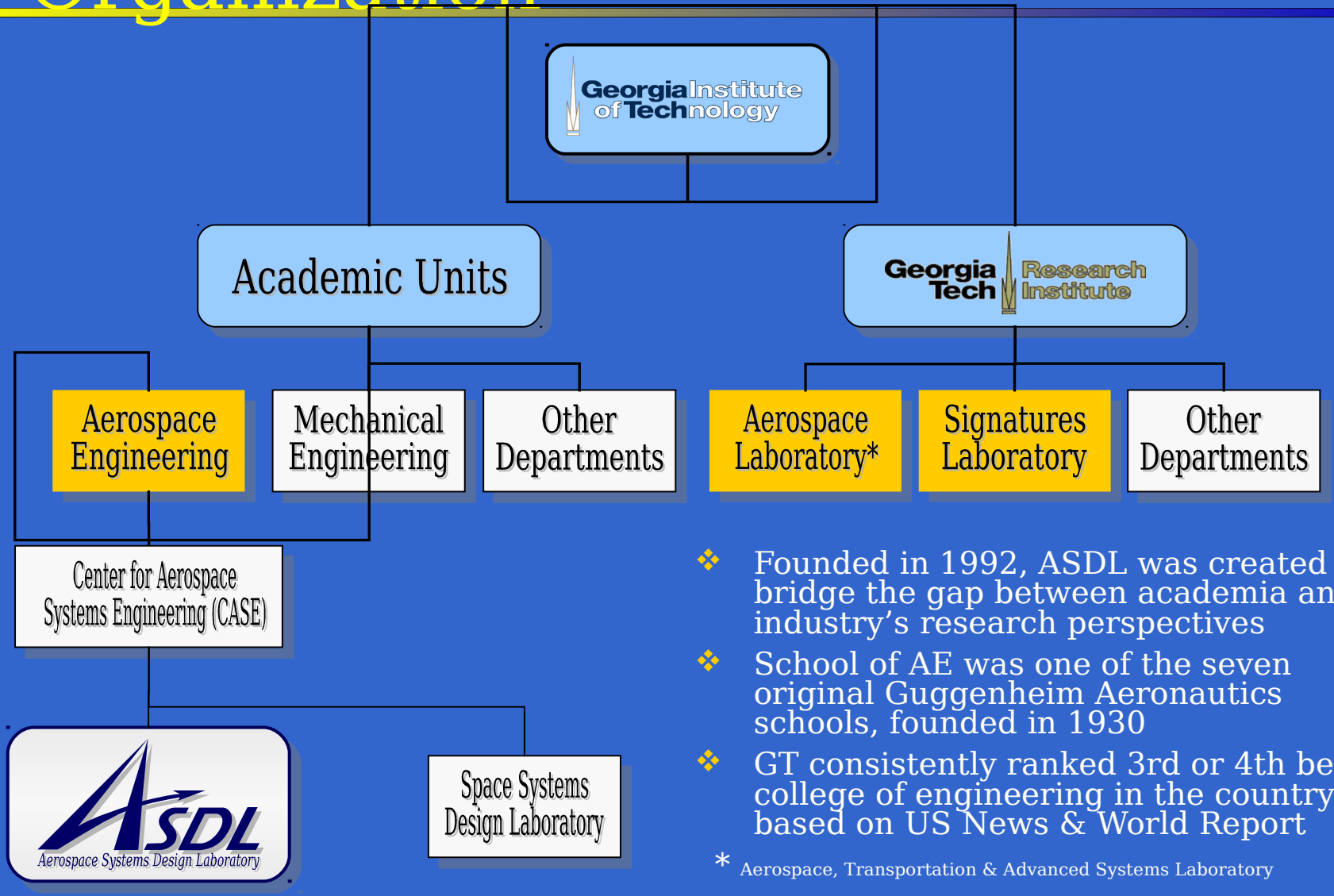


- Founded in 1992, ASDL was created to bridge the gap between academia and industry's research perspectives
- School of AE was one of the seven original Guggenheim Aeronautics schools, founded in 1930
- GT consistently ranked 3rd or 4th best college of engineering in the country based on US News & World Report

* Aerospace, Transportation & Advanced Systems Laboratory

Integration of Strategic Planning, Technology Transition and Technology Development Tools

Program Planning

Strategic Prioritization & Planning (SP2) Tool

Primary Output

Program Definition

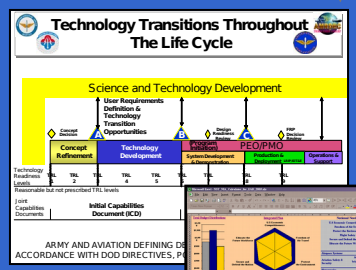
Technology Assessment & Transition Mgt (TATM) Tool

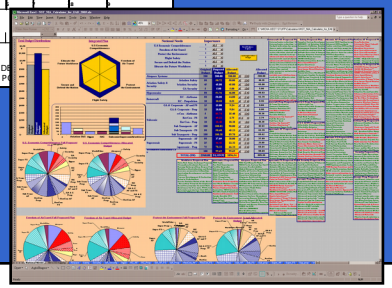
Primary Output

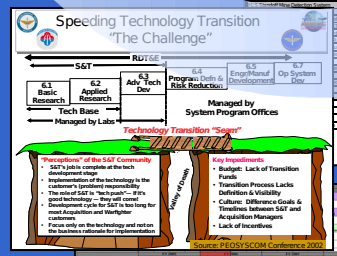
Project Execution

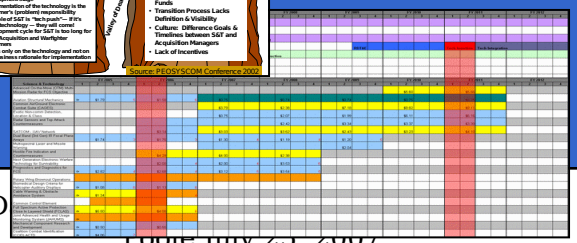
Technology Program Management Model (TPMM) Tool

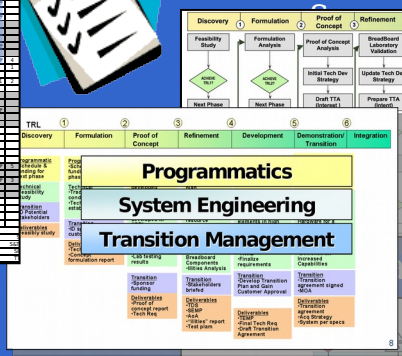
Primary Output

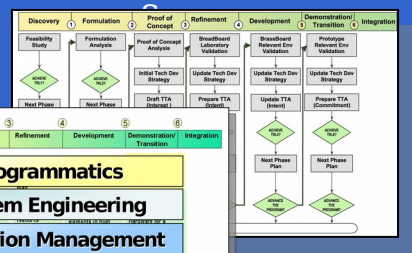


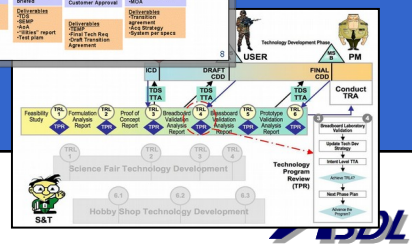












Foundation of SP2 Approach

- The Strategic Planning and Prioritization Calculator (SP2) is an expert-based series of **decision (or planning) matrices** that are related qualitatively through different levels of abstraction and is the detailed process for program planning
- The subjective **qualitative relationships** may then be mapped to **quantitative scales** to allow for a rapid prioritization based on the level of abstraction desired
- The process is an **evolution of accepted quality engineering methods** (i.e. Quality Function Deployment) and incorporates various dynamic aspects to form a portable and powerful decision making environment
- This approach has been effectively used in several recent applications
  - A Congressional study for an integrated 5 year R&T plan for U.S. aeronautics (NIA)
  - The NASA Space Exploration Systems Architecture Study
  - The NASA Vehicle Systems Program (VSP)
  - The Office of Naval Research Science and Technology
  - A Homeland Defense technology application for America's Shield Initiative (SAIC)
  - An upgrade prioritization for the next generation Bradley vehicle (BAE)
  - AIAA Strategic Planning for future activities

Process for Building the Calculator

- The process by which SP2 is developed is fairly **generic** and may be tailored for the specific problem at hand and is based on accepted Quality Engineering Methods
- The "Calculator" is the visual front end
- Regardless of the application, the following elements are necessary to execute the process:
  - **Definition** of top level needs or requirements
  - Description of the **information** desired to facilitate **decision making**, which may include:
    - Schedule, annual or total budgets, source of funding, sensitivity level of abstraction, risk, specific time frames, rack and stack of priorities, etc.
  - **Decomposition** of the needs to the appropriate **level of abstraction**
  - **Qualitatively** relate each level of the decomposition through a series of **planning matrices**
  - Definition of a **quantitative scale** for each level of decomposition and translation to quantitative scales
  - **Identification** of the appropriate domain area **experts** for each level of the decomposition to provide necessary information
- Elements needed for the process can be defined through various techniques and methods including brainstorming, workshops, affinity diagrams, voting methods, relevance trees, Delphi technique, etc.
- The only requirement placed on the process is that a link exists between each level of the decomposition

Features Enabled in SP2

- Program Planning and Technology Selection
- Optimization of partial funding and benefit to cost identification
- Multi-year funding profile capabilities
- Quantification of Technological Risk
- Quantification of Schedule Risk
- Optimization based on Risk
- Identification of Technology and Portfolio Gaps
- Scenario Generation and saving/loading of scenarios
- Statistical Studies (what-if games)

Most common feedback on SP2 has been that communication between different departments now have a forum for communication and collaboration.

Case Study: NIA Aeronautics Calculator

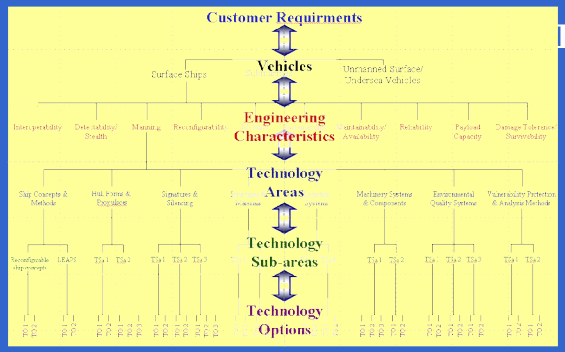
Final product objective:

Develop and deliver to Congress an aggressive 5 year investment plan as a first step to restore aviation and aeronautics technology capabilities to a robust level commensurate with a global leadership position

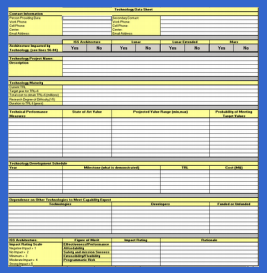
With guidance that:

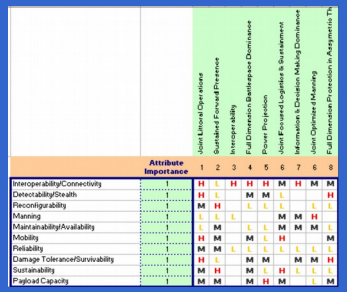
The plan should uniformly seek to mature high-risk, potentially high-payoff technologies to a readiness level sufficient for NASA to transition out of government-sponsored

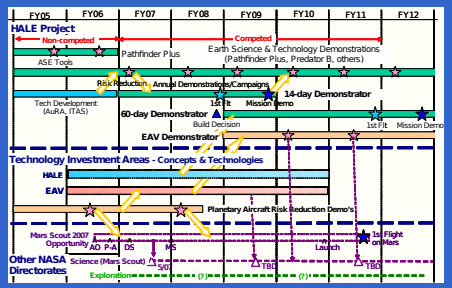
From Vision to Roadmap



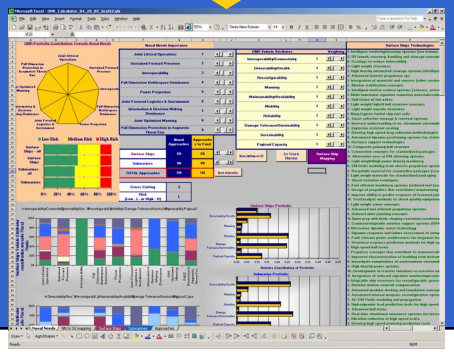
Technology Information Sheet



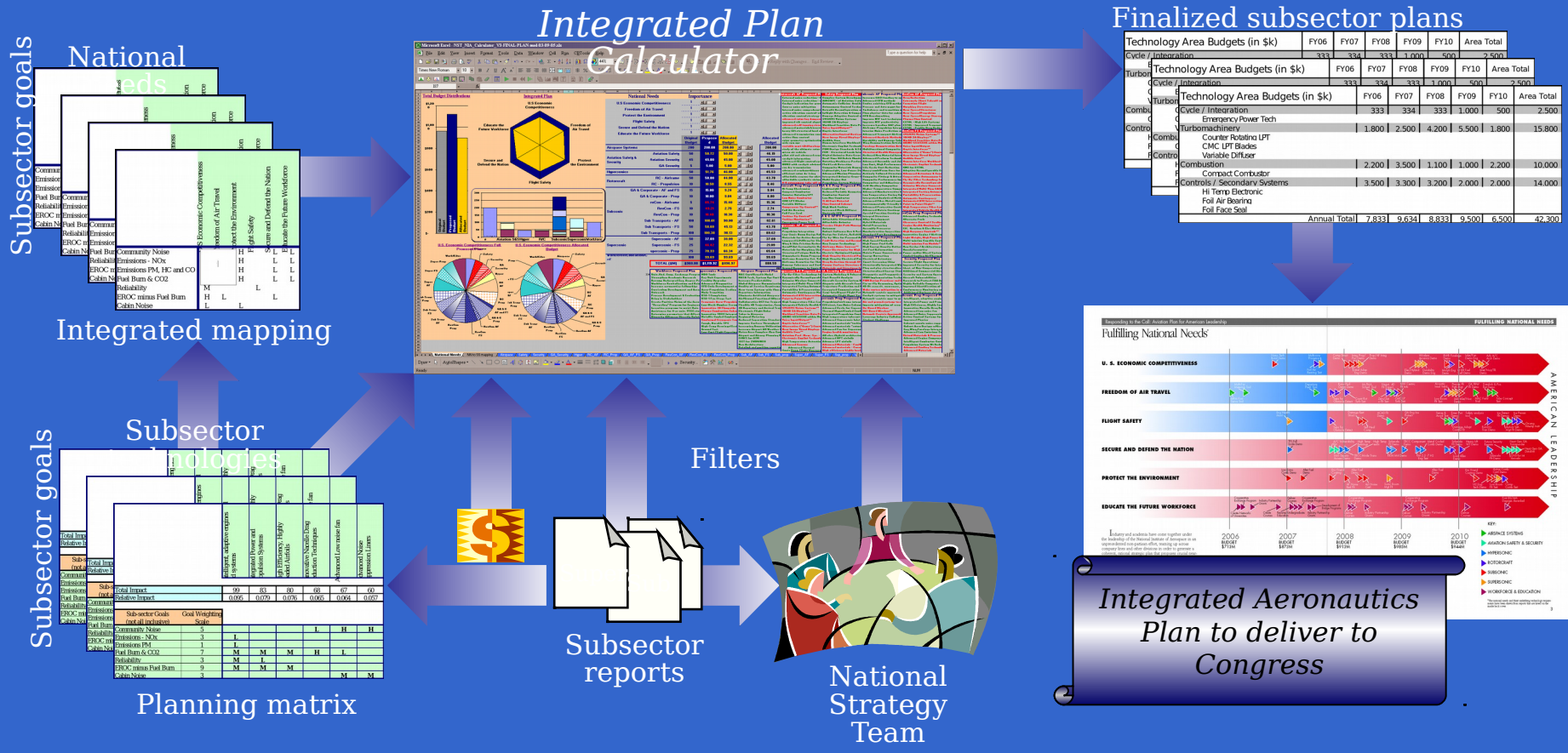




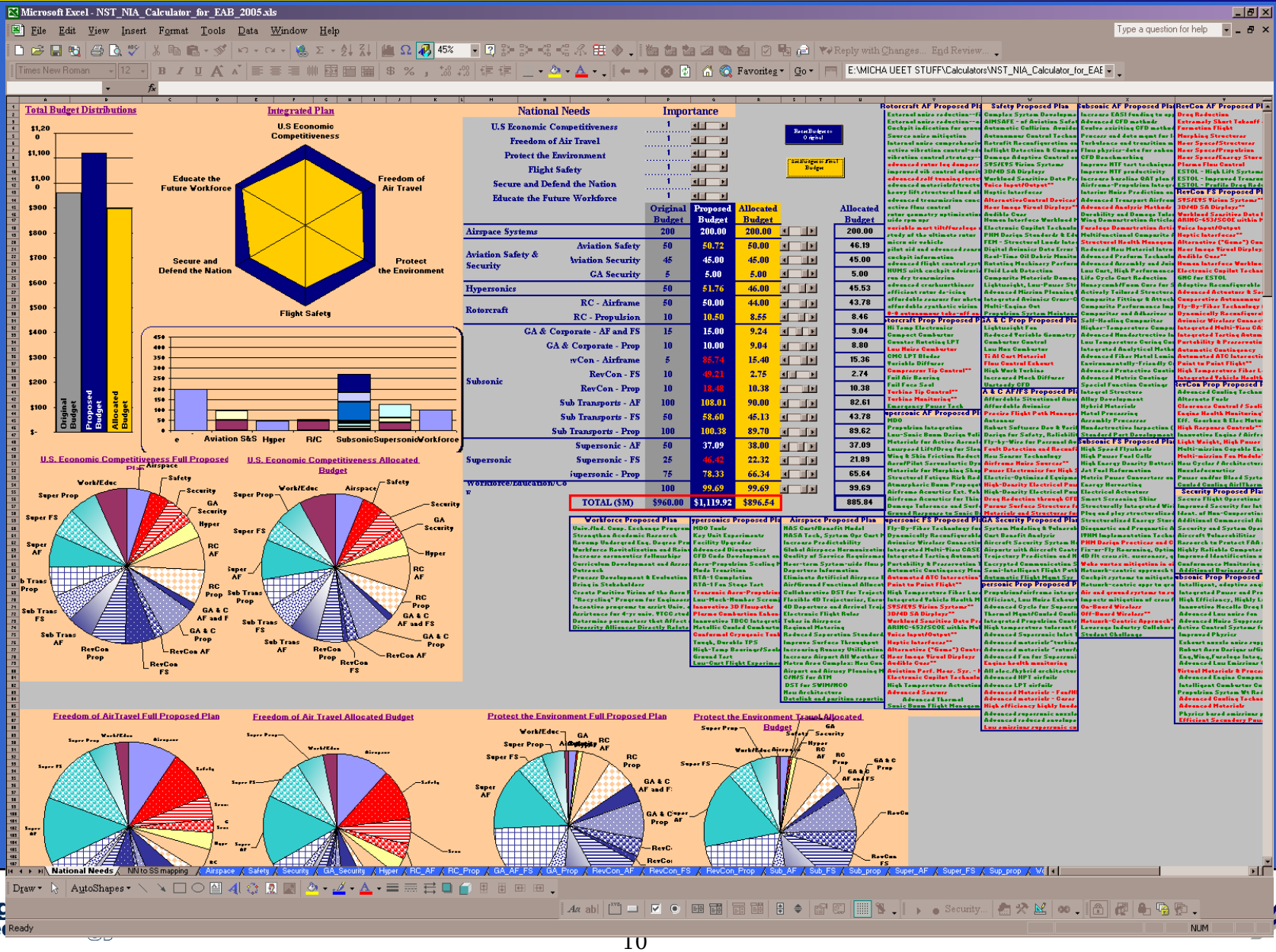
Program Vision | **Customer Requirements Definition** | **Engineering Characteristics Definition** | **Data Call** | **Technology Presentation** | **Validation of Mappings** | **Execute Calculator** | **Create Strategic Roadmap**



Integration Team Objective



Aeronautics Calculator Demo



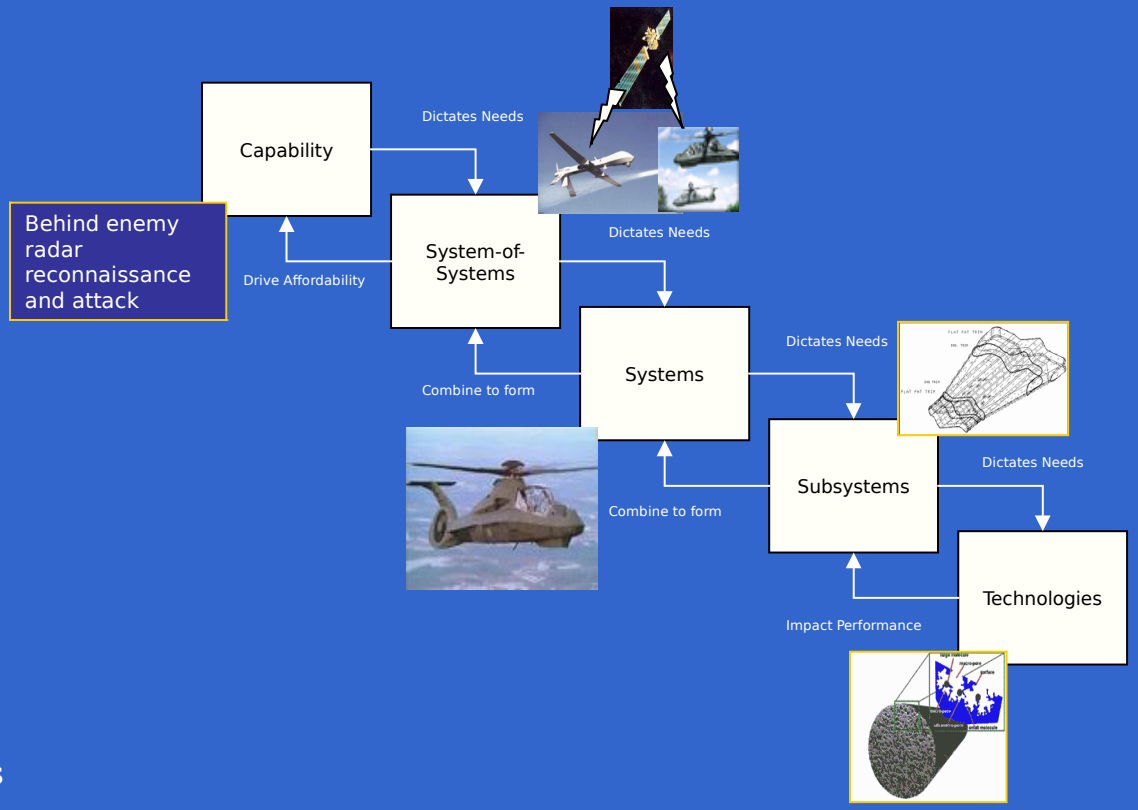
Extending Functionality: Technology to Capability

Technology Push

- S&T programs develop technologies that could be of potential military benefit
- Those technologies must be successfully transitioned to operating units to improve military capability

Capability Pull

- Capability gaps identified by JCIDS
- Pre-Milestone A includes Technology Development Summary
  - Outlines the technologies required for achieving the capability with the alternative selected
  - Provides the plan for maturing those technologies to a TRL of 6
- Technology maturation becomes very closely coupled with the capability and cost of the System-of-systems (

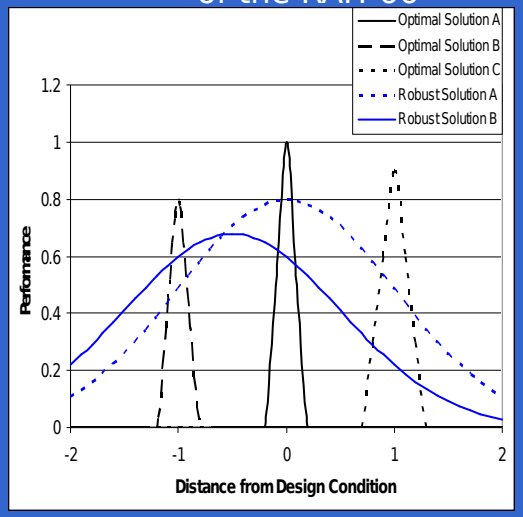


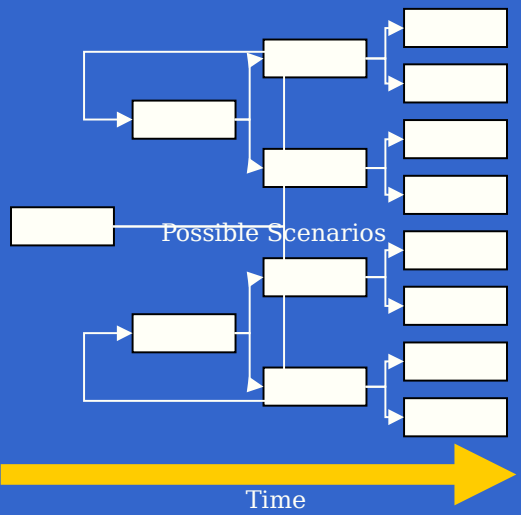
In the capabilities-based resource allocation environment, technologies need to be evaluated based on their anticipated impact at the capability level

Mitigating Risk

- Many sources of uncertainty exist with immature technologies
  - Performance estimates
  - Cost to mature
  - Time to mature
- These uncertainties have the potential to greatly impact the capability, cost, and schedule of a defense acquisition program
- Ensuring robustness helps mitigate risks

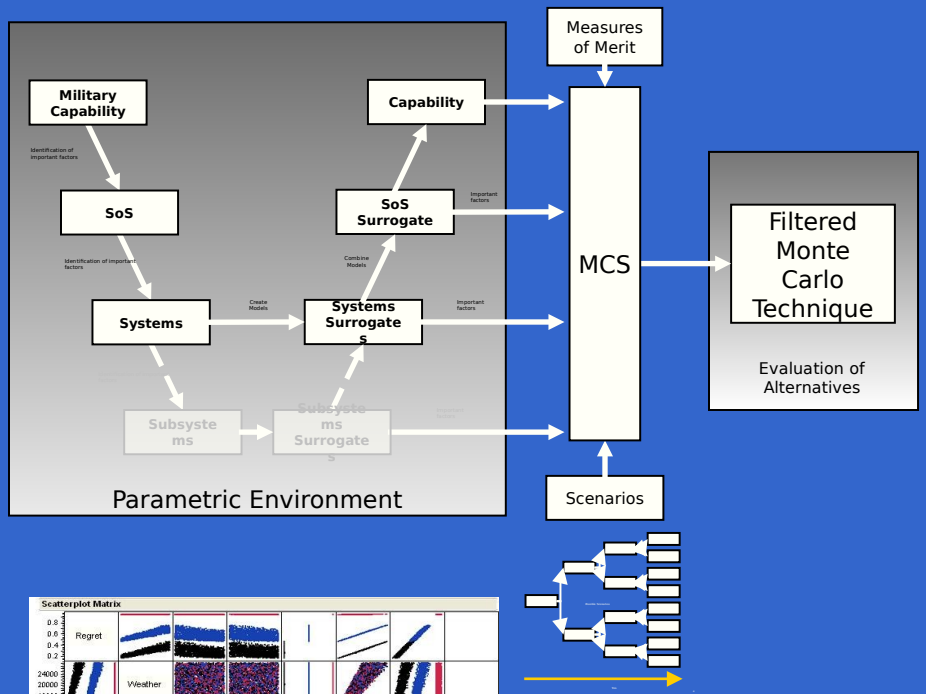
In addition to a changing operational environment, technology maturation to lower-than-expected performance played a large role in the cancellation of the RAH-66

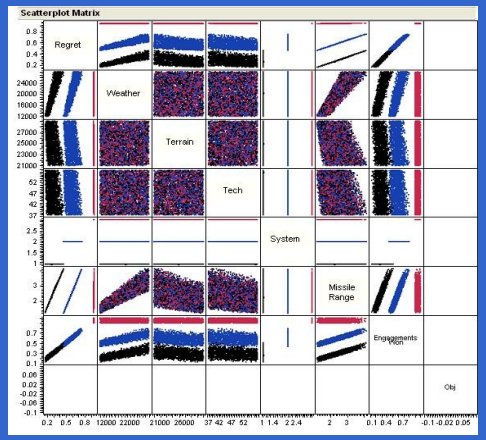




Robust solutions, both in Analysis of Alternatives and Technology Selection, help mitigate the risk associated with immature technologies

Evaluating Robustness





- Robustness
  - Ability of a system, technology or process to perform in off-design conditions
- To evaluate robustness, different scenarios (or possible futures) must be considered
  - Qualitative assessment
  - Quantitative assessment
- The more possible futures examined, the higher the confidence in the robustness of the solution
  - Computer aided scenario generation allows consideration of many more possible scenarios than previously available
- A hierarchical approach to SoS evaluation allows exploration of robustness at all levels of the SoS hierarchy
- Measures of merit must be established that accurately reflect capability needs
  - Robustness is evaluated for those measures of merit

ASDL is developing methods for the quantitative and qualitative assessment of robustness for large numbers of possible futures

SP2 Payoff

- SP2 provides a **structured, traceable, and transparent process** planning and investment prioritization
- The process can be **tailored** to any desired level of detail to enhance the decision making process for investment strategies as more information becomes available
- **Knowledgeable stakeholders** are involved throughout the process
- Various solicitation schemes are used to reduce bias
- The end product will allow for "**what if**" games to be played through a dynamic and interactive environment
- The results of the process can be the **foundation** for detailed **strategic road mapping** and **investment prioritization** for budget development
- SP2 is a living process that should guide strategic planning and be continuously updated as a program evolves

Contact Information

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- Mr. Benjamin Poole
  - PhD Student
  - Benjamin.poole@asdl.gatech.edu

BACKUP

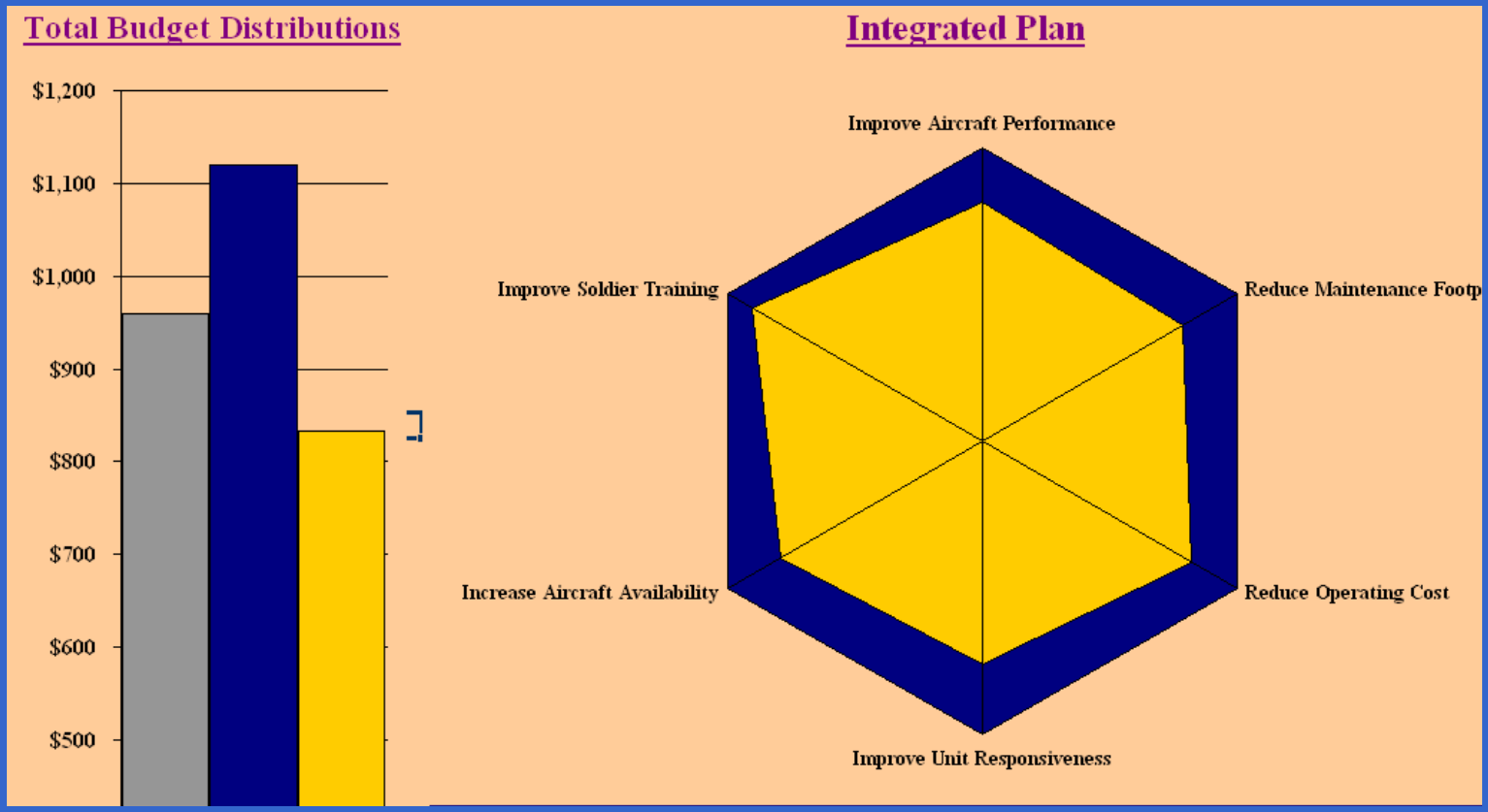
Market Research - Software Capabilities

	Idea Core Solution	Acclaro DFSS	Expert Choice	Dynamic Insight	Calculator
Cost	5100 + Qfd designer	1295	30172.11	6278	
Platform	Windows only	Windows only	Windows only	Windows only	Windows, Mac, Linux
Methodology	QFD	Axiomatic Design	AHP	QFD	QFD
Accountability Tracking	y	y	y	unkonwn	y
Exportability	CSV (Excel)	Office	Office, SQL servers	HTML, Office	Office, HTML

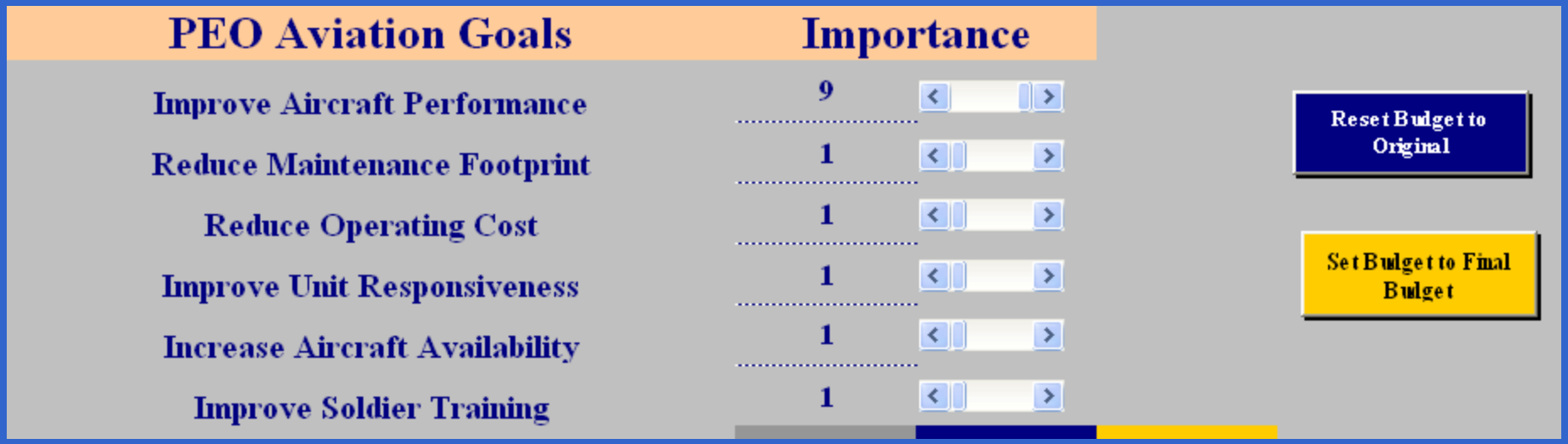
Side-by-Side Software Comparison with SP2 as reference

	Idea Core Solution	Acclaro DFSS	Expert Choice	Dynamic Insight	Calculator
Cost	-	-	-	-	datum point
Platform	-	-	-	S	
Methodology	S	-	-	S	
Accountability Tracking	S	S	S	S	
Exportability	S	S	S	S	
Software Stability	-	unknown	unknown	unknown	
Flexibility	-	unknown	unknown	unknown	
Tailorability	-	unknown	unknown	unknown	
Ease of Use	-	unknown	unknown	unknown	

PEO Aviation - Top Level Goals Visual



PEO Aviation - Top Level Goals & Weightings



PEO Aviation – Intermediate Categories and Bins of Technologies

			Original Budget	Proposed Budget	Allocated Budget	Allocated Budget Used
Utility Helicopter	45% increase in engine HP/WT		200	200.00	136.00	136.00
	18db reduction in transmission noise		50	50.72	50.00	46.19
	35% reduction in production, operating, and support costs		45	45.00	45.00	45.00
	Automatically detect 85% of critical component failures		5	5.00	5.00	5.00
Apache ®		X1	50	51.76	46.00	35.75
		X2	50	50.00	44.00	43.78
		X3	10	10.50	8.55	8.46
		X4	15	15.00	9.24	9.04
Cargo Helicopter		X5	10	10.00	9.04	8.80
		X6	5	85.74	15.40	15.36
		X7	10	49.21	2.75	2.74
		X8	10	18.48	10.38	10.38
UAS		X9	100	108.01	90.00	89.92
		X10	50	58.60	45.13	44.52
Armed Recon Helicopter		X11	100	100.38	89.70	88.18
		X12	50	37.09	38.00	37.09
		X13	25	46.42	22.32	21.89
Aviation Systems		X14	75	78.33	66.34	65.58
		X15	100	99.69	99.69	99.69
	TOTAL ($M)		$960.00	$1,119.92	$832.54	818.61

PEO Aviation - Bins of Technologies

V	W
45% increase in engine HP/WT	X4
Oil Free Engine Technology	Y260
Efficient, high-power-density engine	Y261
Integrated high performance turbine	Y262
Active-flow control technology	Y263
Increased Turbine Inlet Temp	Y264
Advanced Composite Turbine Blades	Y265
Emission Gas Reuse	Y266
Spun Carbon Frame	Y267
High Efficiency Combustion	Y268
Vibration Control	Y269
Advanced Structural Design	Y270
Structural Load Alleviation	Y271
Advanced Composite Shaft	Y272
Inlet Flow Control	Y273
Reconfigurable Inlet	Y274
Variable Operating RPM	Y275
Efficient Compressor Staging	Y276
Compressor Composites	Y277
Fuel Additives	Y278
Engine Sensors	Y279
Low Temp Exhaust	Y280
Lightweight Fuel Lines	Y281
Structural Synergy	Y282
Bearingless Shaft	Y283
Radial Compressor	Y284
Single Shaft Compressor	Y285
Decreased Tolerances	Y286
Lightweight Burner	Y287
Improved Combustor Swirling	Y288
18db reduction in transmission noise	X5
Optimized gearbox/engine system tec	Y22

Improved Combustor Swirling	Y288
18db reduction in transmission noise	X5
Optimized gearbox/engine system tec	Y22
Variable/multi-speed drive system te	Y23
Active rotor control (of vibration and	Y24
Low Noise Gearbox	Y25
Electronic Transmission	Y26
Transmission Insulation	Y27
Lightweight Shaft	Y28
Higher Transmission Tolerance	Y29
Y1	Y30
Y2	X6
Y3	Y5
Y4	Y6
35% reduction in production, operating, and	

Traditional Resources Allocation Approaches

Due to limited Research and Development (R&D) monies available, the decision-maker desires to know where to direct scarce resources to maximize technological payoffs or substantiate strategic competitive decisions. Five traditional approaches are (Cetron [1972]):

1) ***Squeaking Wheel***: cut resources from every area and then wait and see which
area complains the most. Based on the loudest and most insistent, then
restore budget until ceiling is hit.
2) ***Level Funding***: budget perturbations minimized and status quo maintained; if
this approach continues within a rapidly changing technology field, the
company, group, or agency will end up in serious trouble.
3) ***Glorious Past***: "once successful, always successful". Assign resources solely on

National Strategy Team

- The purpose of the NST was to:
  - set the Strategic Agenda for the overall analysis, planning and integration activities
  - define 6 over-arching National Needs which were based on the blue-ribbon documents
  - set the research scope and priorities for each of the aviation sectors, including target budgets so as to frame the scope of research
  - provide oversight of the planning activities
  - provide guidance for the preparation and roll-out of a final product
- Members included:

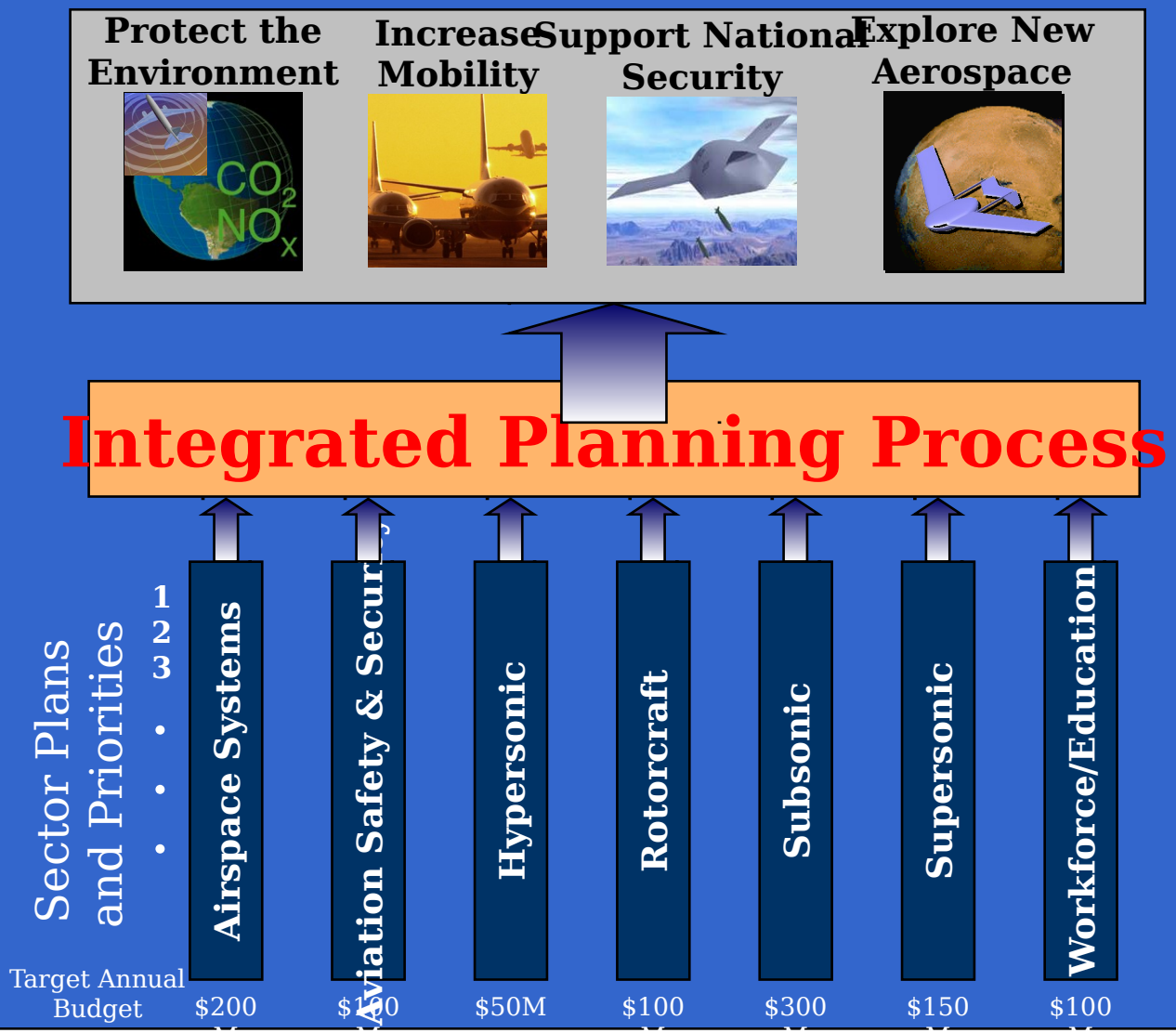
Name	Title	Organization
Bob Krieger*	President	Phantom Works, The Boeing Company
Simeon Austin	Dir of Advanced Prgs	Pratt & Whitney
Mike Benzakein	General Manager	Advanced Technology Operations, GE Aircraft Engines
Earl H. Dowell	J. A. Jones Professor	School of Engineering, Duke University
Ed Glasgow	Technical VP	Advanced Development Programs, Lockheed Martin Aeronautical Company
Norris Krone	President	University Research Foundation, Maryland Advanced Development Laboratory
Robert G. Loewy	Chair	School of Aerospace Engineering, Georgia Institute of Technology
Walter O'Brien	J. Bernard Jones Prof	Mechanical Engineering, Virginia Polytechnic Institute and State University
Kevin J. Riley	VP for Technology	Raytheon Company, Network Centric Systems

* Chairman of the NST

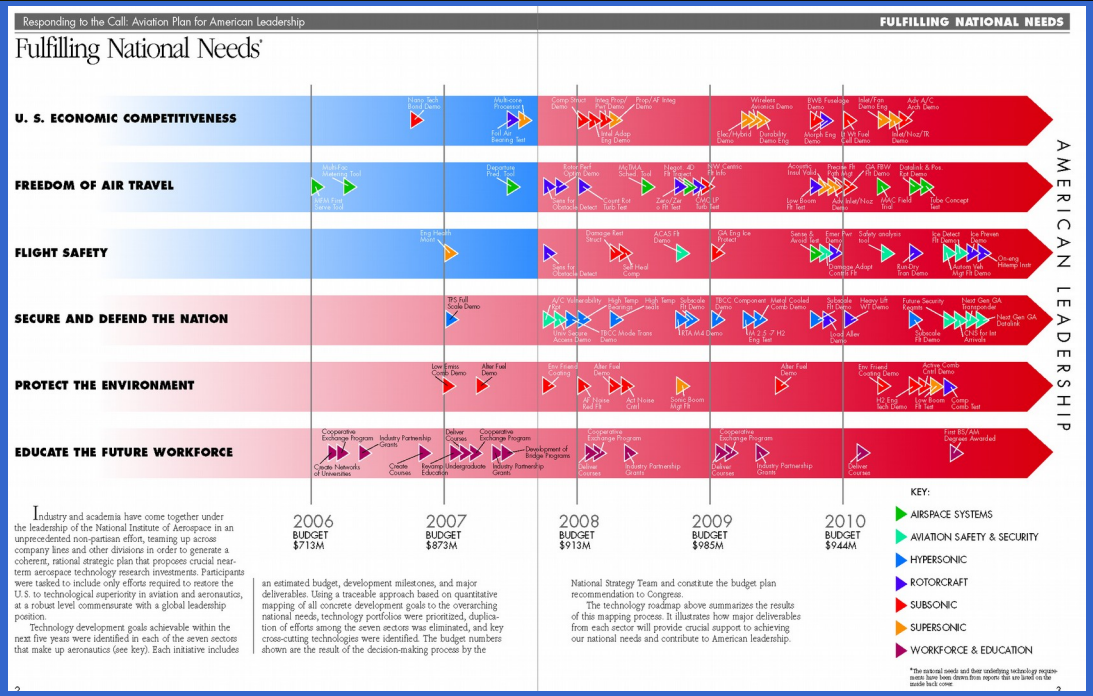
Integrating the Aeronautics Plan

ASDL Involvement:

- Contracted to be the primary integrator of all the sector plans
- Interacted with each contractor to provide continuity amongst the teams on a daily basis
- Provided guidance and information when needed
- Provided a decision making tool to the NST to determine the final plan to be presented to Congress
- Collaborated with the production

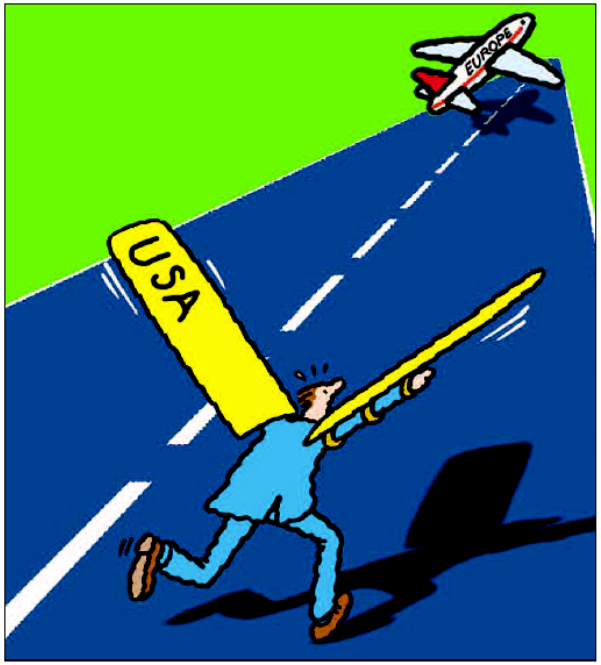


The Aeronautics Plan



- The final brochure was a 16 page document that highligh the plan and calls out for our government to re-establish aeronautical funding in the U.S. to a level commensurate with a global leadership position
- The integrated plan was more than 1,100 pages
- The brochure was distributed to congressional staffers fo the past several months and stimulated hearings and awareness of the budget crisis

This will be the future of American aviation without dramatic action by the U.S. Congress...

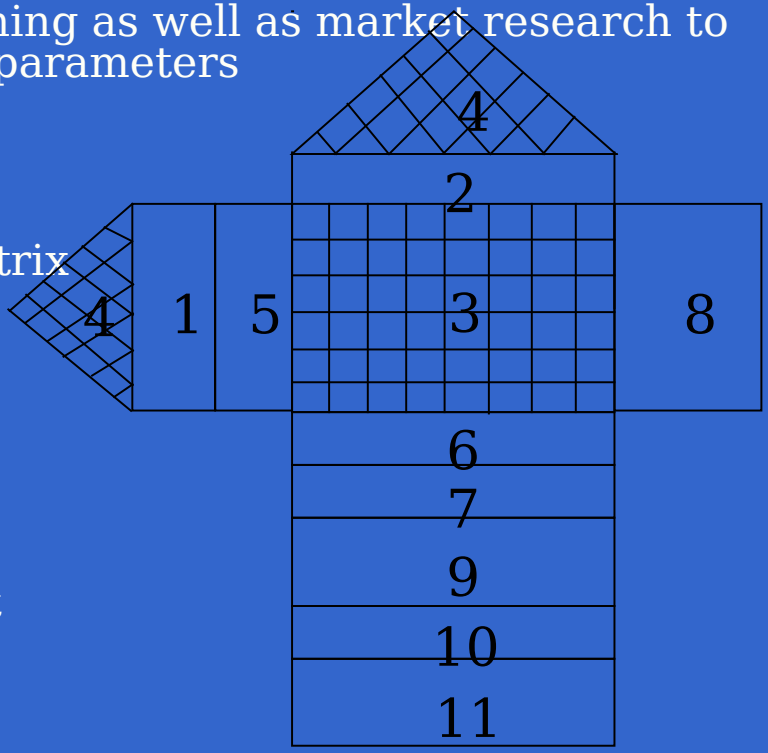


National Institute of Aerospace
April 2005

Calculator Functional Background

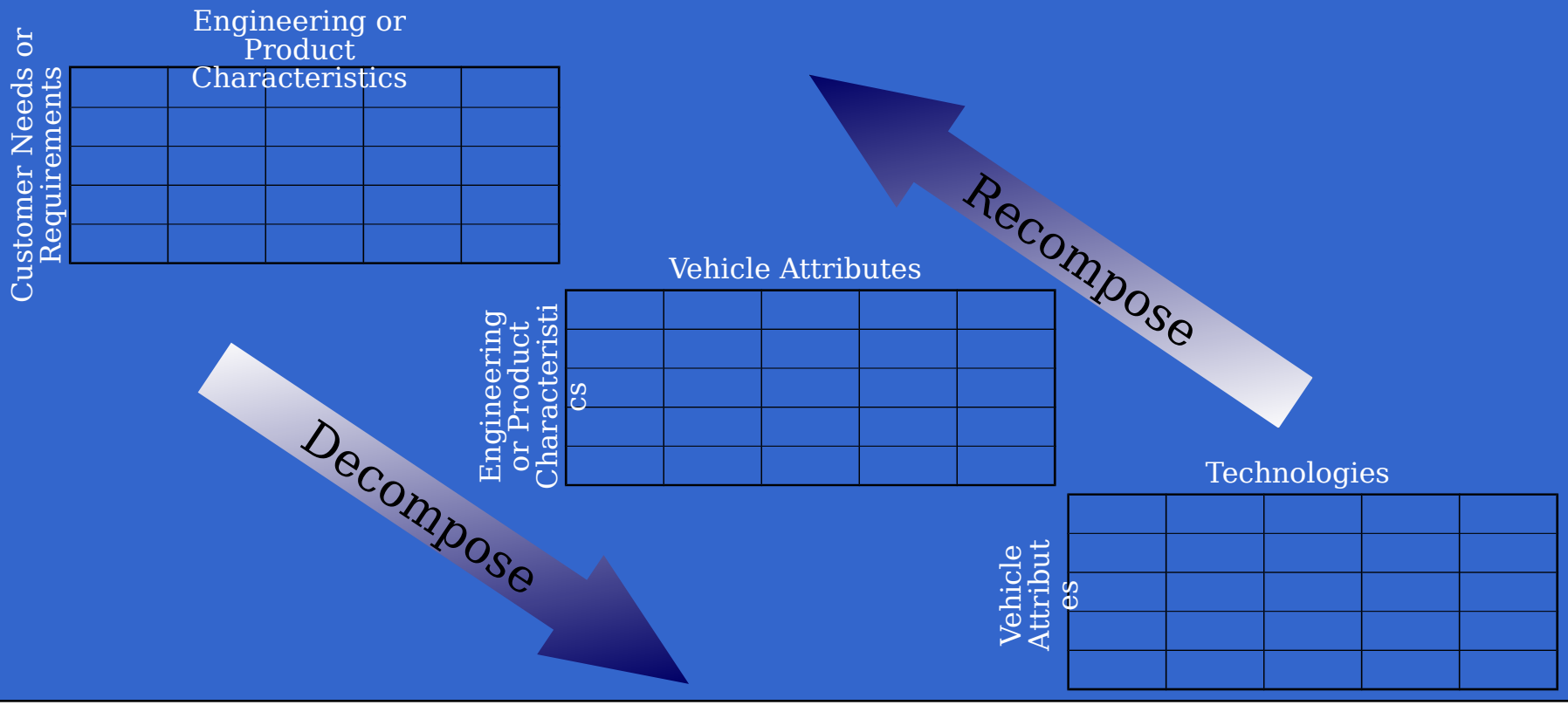
- Much of the calculator background stems from the Quality Functional Deployment (QFD) Methodology (Sanchez [1993])
- This technique combines many qualitative measurements of relationships and interdependencies between different parameters into a clear representation of importance
- Uses teamwork and creative brainstorming as well as market research to identify customer demands and design parameters

1 - Customer Requirements
2 - Engineering Characteristics
3 - Relationship (or planning) Matrix
4 - Correlation Matrix
5 - Importance Rating
6 - Absolute Importance
7 - Relative Importance
8 - Competitive Assessment
9 - Tech. Competitive Assessment
10 - Technical Difficulty
11 - Target Values

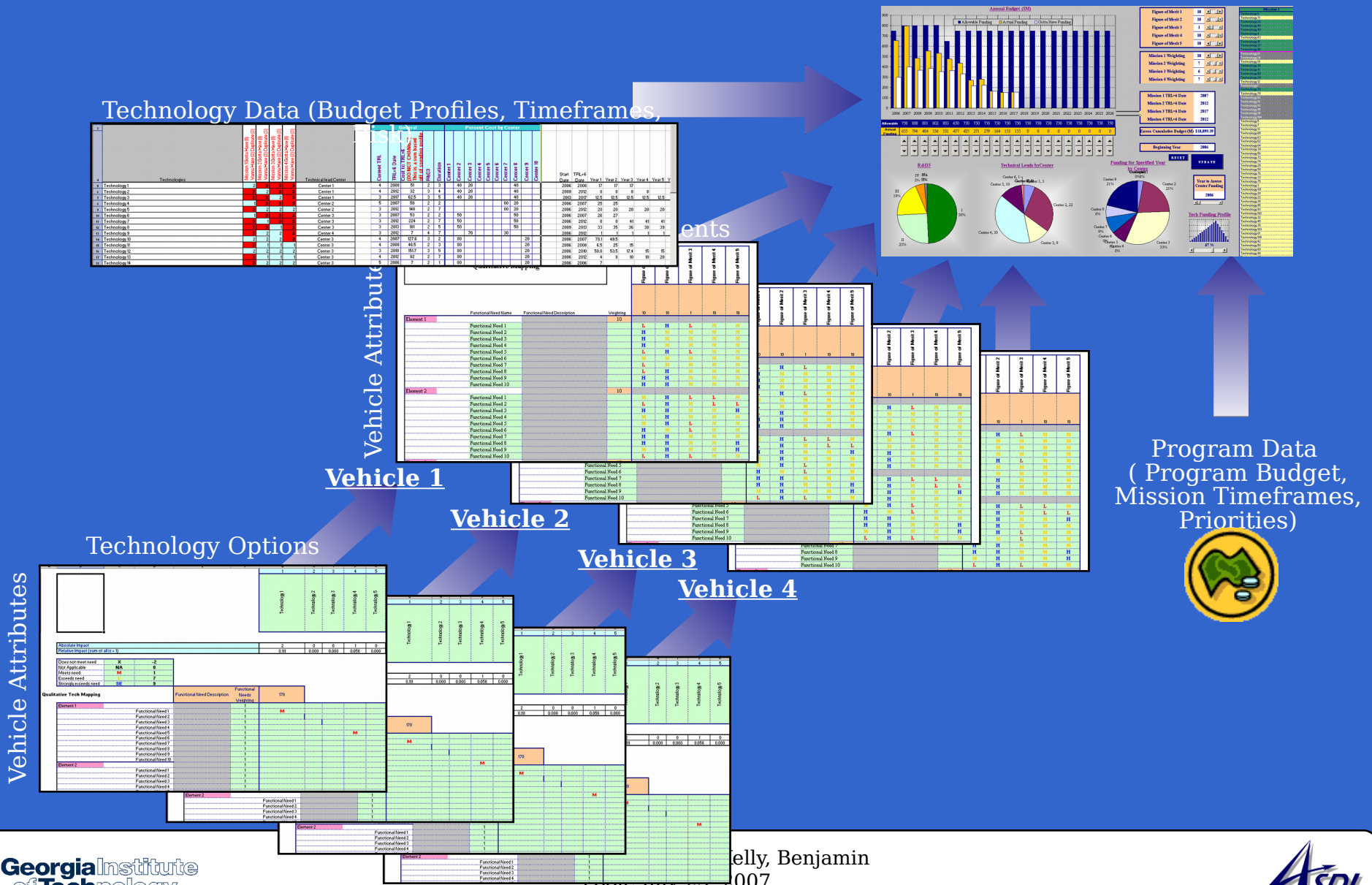


Calculator Functional Background

- Much like the QFD Methodology, the Calculator process allows for multiple layers of abstraction to be combined
- Final outcome allows technologies to be ranked based on impact to the overall needs when direct relationships are not clear
- While the mapping between levels in a matrix can be qualitatively done, there must be a conversion to qualitative information before the data can be related a different level



Notional Calculator Overview



Technology Planning Matrices

- The Technology Planning Matrix qualitatively relates how the technologies and the vehicle attributes interact
- Vehicle attributes are the qualities of the vehicle that are directly impacted by the technologies and themselves affect the overall figures of merit
- Technologies' relations to the attributes are qualitatively assigned and can be quantized on a scale fitted to the particular application
- Vehicle attributes can be weighted in order to establish a relative priority amongst those identified

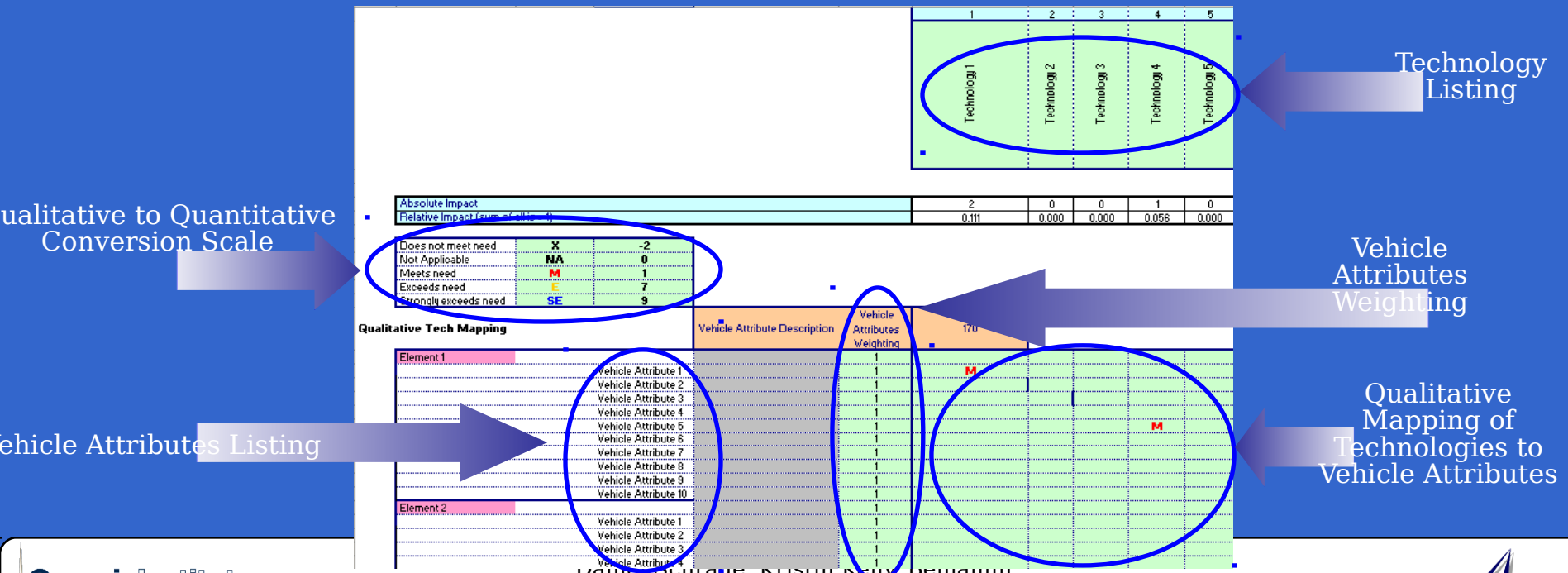
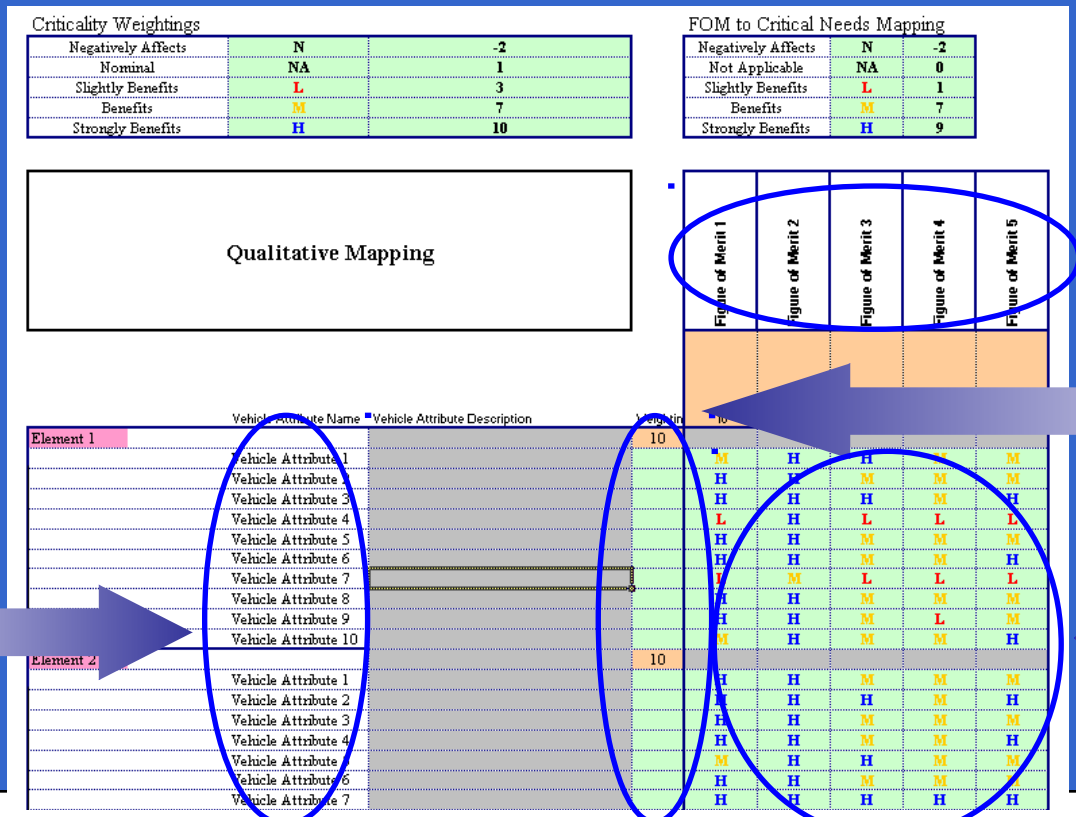


Figure of Merit Mapping Matrix

- The Figure of Merit Mapping Matrix qualitatively tracks the impact of the vehicle attributes to the overall figures of merit
- These figures of merit are the top level metric which will be used to rank and evaluate a portfolio of technologies
- Functional needs can be assigned criticality weightings based on their overall importance to accomplishing the specified missions

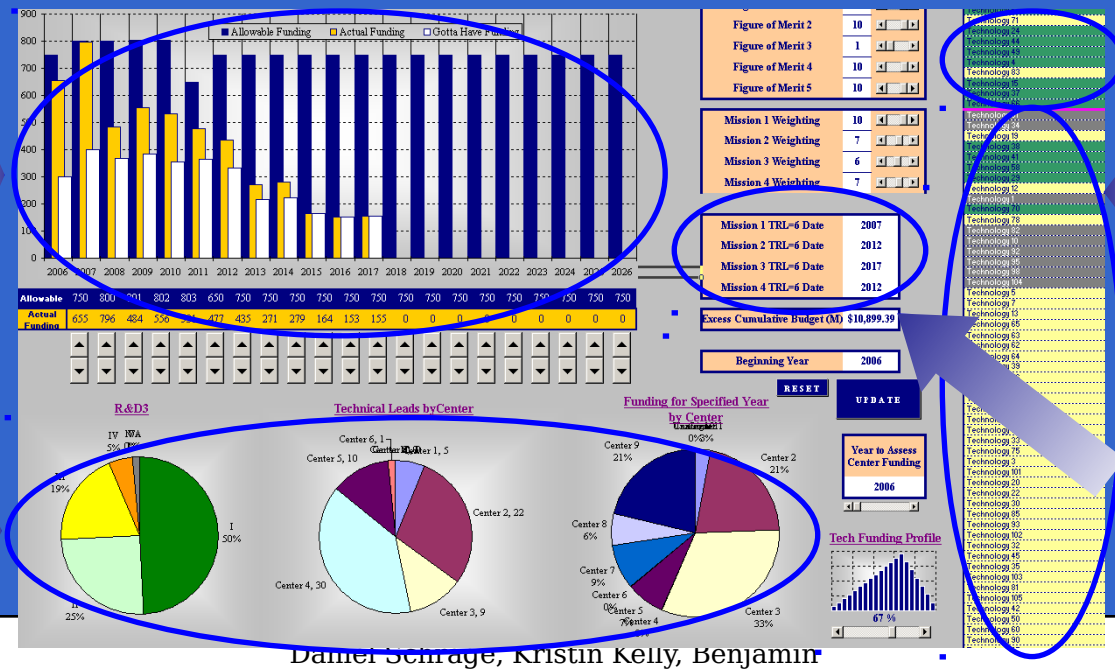


Technology Data

- Proper budget and timeframe analysis requires certain types of data to be supplied to the calculator for every technology of interest
  - Budget profile detailing the amount of funding required per year to obtain a TRL of 6
  - If a budget profile is unavailable then one may be generated if the total cost of the program and the time until TRL 6 is reached are given
- Additional information such as risk and funding splits can be supplied for more in depth visuals and decision making processes but are not required for initial calculator computation

Technology Prioritization

- Once the mapping decisions are made and the data is provided for the technologies then the front end can be used to perform various trade studies and find the optimum technology portfolio
- Variable sliders exist to allow the user to adjust rankings and budget profiles on the fly
- The technologies can then be prioritized to meet the allocated budget
  - "Gotta have" technologies are automatically included in the portfolio such that they are available for the mission cutoff date
  - "Wanna have" technologies are selected for inclusion based off their impact on the figures of merit as calculated from the technology planning matrix and the figures of merit mapping matrix



"Gotta Have" Technologies In order of impact

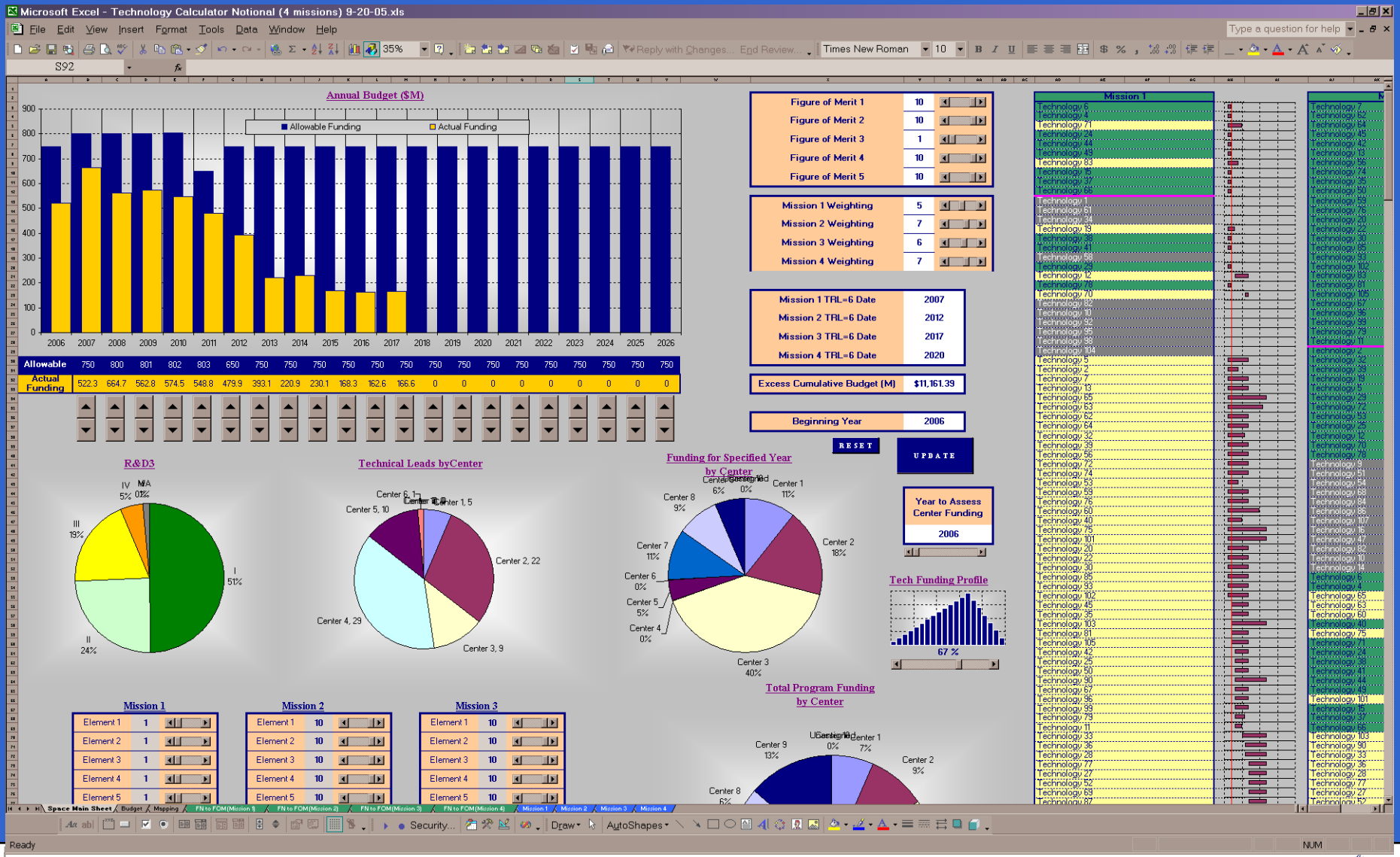
"Wanna Have" Technologies In order of impact

Total Program Budget Profile

Visuals for current Technology Portfolio

Mission Technology Readiness Dates

Notional Calculator



ASDL Visualization Research Facilities

- Collaborative Visualization Environment (CoVE)
  - An 18’x10’ “war room” type display wall with 12 PCs at operator consoles
  - Comprised of a “seamless” 4x3 matrix of 67” rear-projection LCD screens
  - For use in critical reviews by design decision-makers and stakeholders
  - Facilitates research in advanced engineering data visualization techniques

CoVE

- Collaborative Design Environment (CoDE)
  - Work areas for integrated product teams
  - Includes computer workstations, interactive whiteboards, and a smaller display wall
  - Linked to CoVE for use by design disciplinarians in support of critical reviews
- High-performance computational support
  - 256-processor cluster with 512 GB RAM, 5 TB storage, gigabit Ethernet and Infiniband high-speed communication backbones
  - Supports CoVE, CoDE, and research requiring high-speed or parallel computing
  - Hardware provided through an ONR DURIP grant in 2004